

PATENT COOPERATION TREATY

PCT NOTIFICATION OF ELECTION (PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
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Arlington, VA 22202
ETATS-UNIS D'AMERIQUE
in its capacity as elected Office

Date of mailing (day/month/year) 21 February 2001 (21.02.01)	Applicant's or agent's file reference OP0406/ANR
International application No. PCT/FI00/00644	Priority date (day/month/year) 14 July 1999 (14.07.99)
International filing date (day/month/year) 13 July 2000 (13.07.00)	
Applicant HAGSTRÖM, Panu	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
16 January 2001 (16.01.01)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Nestor Santesso Telephone No.: (41-22) 338.83.38
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FI0000644

10/030555

PATENT COOPERATION TREATY

PCT

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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference OP0406/ANR	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/FI00/00644	International filing date (day/month/year) 13.07.2000	Priority date (day/month/year) 14.07.1999
International Patent Classification (IPC) or national classification and IPC ₇ H 04 B 1/40, H 01 Q 1/38, H 04 Q 9/04		
Applicant FILTRONIC LK OY et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.	
2. This REPORT consists of a total of <u>3</u> sheets, including this cover sheet.	
<input type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).	
These annexes consist of a total of _____ sheets.	
3. This report contains indications relating to the following items:	
I	<input checked="" type="checkbox"/> Basis of the report
II	<input type="checkbox"/> Priority
III	<input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	<input type="checkbox"/> Lack of unity of invention
V	<input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	<input type="checkbox"/> Certain documents cited
VII	<input type="checkbox"/> Certain defects in the international application
VIII	<input type="checkbox"/> Certain observations on the international application

Date of submission of the demand 16.01.2001	Date of completion of this report 12.11.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 33	Authorized officer Bo Gustavsson/AE Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/FI00/00644

I. Basis of the report

1. With regard to the **elements** of the international application:*

- ☒ the international application as originally filed
- ☐ the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the drawings:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language _____ which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

- ☐ the description. pages _____
- ☐ the claims. Nos. _____
- ☐ the drawings. sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

** Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/FI00/00644

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. Statement**

Novelty (N)	Claims	<u>1-6</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-6</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-6</u>	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The invention relates to an integrated structure of a radio frequency front-end of a communications apparatus and a communications apparatus using said front-end structure.

The claimed invention according to claims 1-6 has novelty and is considered to involve an inventive step in view of the documents cited in the International Search Report.

Documents cited in the International Search Report:

D1	DE 19813767 A1
D2	EP 0766410 A2
D3	US 4792939 A
D4	US 5404581 A

The documents cited in the International Search Report represent the prior art. The claimed invention stated in claims 1-6 is not considered to be anticipated by these documents. None of the documents or any relevant combination of them reveal a front-end or a communications apparatus as described by these claims.

According to the arguments stated above, the invention claimed in claims 1-6 is novel, considered to involve an inventive step and have industrial applicability.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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18 January 2001 (18.01.2001)

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H01Q 1/38, H04Q 9/04

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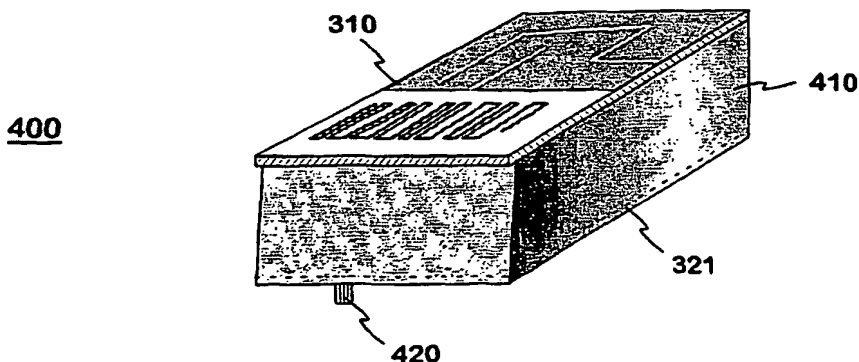
(81) Designated States (national): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ,
DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR,
HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR,
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Published:
— With international search report.

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: STRUCTURE OF A RADIO-FREQUENCY FRONT END



(57) Abstract: The invention relates to an integrated structure of a radio-frequency front end of a communications apparatus. The antenna of the communications apparatus is constructed on a printed circuit board. To this antenna board (310), on its ground plane side, a second circuit board (321) is attached by means of a rigid protective frame (410), which second circuit board includes the other parts of the radio-frequency front end. Between the parts impedance levels are used that are appropriate from the electrical operation perspective. All said parts together form an integrated component (400) to be located inside the housing of the communications apparatus. The advantage of the invention is that it requires a smaller number of components needed for matching between the RF parts, and makes possible a greater sensitivity of the receiver as well as a better transmitter efficiency than prior art structures.

WO 01/05048 A1

Structure of a radio-frequency front end

The invention relates to an integrated structure of a radio-frequency front end in a communications apparatus. The front end comprises at least an antenna as well as a radio-frequency amplifier and filter both in the transmit and receive branch.

- 5 Several filters are needed in the radio-frequency part of a bi-directional radio apparatus such as a mobile station. Extra frequency components produced by a mixer as well as extra frequency components produced by a power amplifier have to be removed in the transmit branch. In the receive branch, filters are needed in order to achieve basic selectivity, protect a low-noise pre-amplifier, and to attenuate noise
10 generated by the transmitter on the receive band. In the case of different transmit and receive frequencies a duplex filter is generally used to mutually separate the different directions of transmission. An antenna switch is used in systems in which the transmit and receive frequencies are the same, and in systems where transmission and reception take place both at different frequencies and at different
15 moments of time. Other functional units in a radio-frequency front end include the aforementioned amplifiers, a directional coupler for measuring the transmission power for power control, and mixers.

- Integration of successive radio-frequency units is difficult mainly because of the relatively large size of the filters. If, for example, an antenna switch, a low-noise
20 amplifier (LNA) and a filter between them are integrated on one chip, the large size of the filter calls for relatively large connection strips that produce electrical stray quantities and inductive couplings which degrade the selectivity of the filter. Complete integration of a filter between active RF units with other units is therefore impractical.

- 25 Another thing that makes integration difficult is the fact that commercial components usually have input and output impedances of 50 Ω in order to make modular design easier. However, advantageous values for RF circuit input and output impedances are often different: for example, the optimum input impedance level of a LNA is about 100 to 200 Ω . If the amplifier has this input impedance, the matching to the
30 standard impedance of the preceding circuit requires a separate matching circuit. This will increase both the size and cost of the radio apparatus. Moreover, the matching circuit causes additional losses on the signal on the transmission path, which, in turn, means a shorter talk time, among other things.

From the prior art it is known numerous structures aimed at achieving as high degree of integration of RF circuits as possible. Radios according to the prior art usually comprise at least one integrated component and discrete filters connected to it/them.

5 Patent document WO 93/14573 discloses a solution applicable to time division multiple access wherein all active components of the transceiver are integrated into a single circuit. A disadvantage of this solution is that there are matching problems between the integrated circuit and the filters external to it. In addition, the integrated circuit does not contain a directional coupler. An external directional coupler built
10 into a printed circuit board is susceptible to electric disturbances, requires a considerable amount of space on the printed circuit board and, in addition, causes an extra loss of at least 0.5 dB in the transmitter chain, which has a direct impact on the current consumption of the communications apparatus.

From U.S. Patent No. 4,792,939 a solution is known in which a duplexer,
15 transmitter and receiver are integrated on one chip. In that solution the duplexer, a bandpass filter and a mixer are implemented using surface acoustic wave (SAW) technology. A drawback of the arrangement is that the matching circuits required by the SAW circuits are so large and the SAW circuits themselves are so lossy and have such a poor power capacity compared to the transmission power that
20 application of the solution in a modern mobile phone is impossible.

U.S. Patent No. 5,432,489 discloses a solution that uses transmission lines belonging to circuits of the transmitter branch bandpass filter or to matching circuit, as part of a directional coupler. This way, the directional coupler can be moved from the printed circuit board onto a low-loss substrate and inside the protective
25 housing of the high-frequency filter. The advantage of the solution is that it saves space and reduces susceptibility to interference as well as the transmission loss caused by the directional coupler, but the disadvantage is that in other respects the integration problems remain.

From U.S. Patent No. 5,903,820 it is known a solution in which an antenna filter
30 AFI, antenna switch ASW, directional coupler DCO, low-noise amplifier LNA, mixers MIX, and a power amplifier PA are integrated into one entity. This entity forms one component on the printed circuit board of a mobile station. Fig. 1a shows a block diagram of said entity 10, which is to be integrated. Fig. 1b shows an example of the practical implementation of the circuit 10. In the example, all parts

are assembled onto one and the same low-loss substrate S. The most space-consuming parts are the coaxial resonators 11 and 12 that form the most significant part of the antenna filter AFI. The parts are located inside a common housing SH that protects them from interference.

- 5 An advantage of the structure according to Fig. 1 is that the number of structural elements needed for matching at the input of amplifier LNA and output of amplifier PA is smaller as there is no need to provide matching to the 50 Ω impedance level. Additional advantages include a reduction of parasitic effects, reduction of the number of components inserted onto the printed circuit board of the
10 communications apparatus and reduction of the area needed on the circuit board. A drawback of the structure is that the transmit branch bandpass filter 20 and receive branch bandpass filter 30, shown in Fig. 1a, are still separate units on the circuit board. The antenna, too, is a discrete component.

- 15 An object of the invention is to reduce the above described disadvantages of the prior art. The structure according to the invention is characterized by what is expressed in the independent claim. Preferred embodiments of the invention are disclosed in the other claims.

- 20 The basic idea of the invention is as follows: The antenna of the communications apparatus is constructed on a printed circuit board. To the antenna board, on its ground plane side, a second printed circuit board is attached by means of a rigid protective frame, which second circuit board includes the other parts of the radio-frequency front end. Between the parts impedance levels are used that are appropriate from the electrical operation perspective. All said parts together form a solid component to be located inside the housing of the communications apparatus.

- 25 An advantage of the invention is that the number of structural elements needed for matching between the RF parts is smaller than in prior-art structures. Another advantage of the invention is that it makes possible a greater sensitivity of receiver than prior art structures. The noise figure and the sensitivity of the receiver branch can be improved by means of internal optimization, for example. A further
30 advantage of the invention is that it makes possible lower losses in the transmitter than prior art structures. For example, changing the input impedance of the power amplifier PA from 50 Ω to 2 Ω makes the design of the power amplifier considerably easier, at the same improving the efficiency of the power amplifier. Still another advantage of the invention is that it provides a single component that comprises the

whole radio-frequency front end including the antenna. This leads to smaller communications apparatus and simplification of design.

The invention will now be described in detail. Reference will be made to the accompanying drawing wherein

- 5 Fig. 1a shows in the form of block diagram an example of the front end of a communications apparatus,
Fig. 1b shows an example of the practical implementation of the prior-art front end according to Fig. 1a,
Fig. 2 shows in the form of block diagram a second example of the front end of
10 a communications apparatus,
Fig. 3a shows an example of an antenna board according to the invention,
Fig. 3b shows an example of a placement according to the invention of functional modules, and
Fig. 4 shows in the form of component an example of a front end according to
15 the invention.

Figs. 1a and 1b were already discussed in connection with the description of the prior art.

- Fig. 2 shows a block diagram of a possible radio-frequency front end of a communications apparatus. The front end 200 comprises an antenna 210, duplex filter 220,
20 low-noise amplifier 230, bandpass filters 241 and 242, and a power amplifier 250. The antenna is connected to a bi-directional antenna port in the duplex filter 220. The receive port of the duplex filter is connected to the input of the amplifier 230, and the output of the amplifier 230 is connected to the input of the bandpass filter
25 241. The output of the filter 241 is connected to the receive branch mixer, and the input of the filter 242 is connected to the transmit branch mixer. The output of the filter 242 is connected to the input of the amplifier 250, and the output of the amplifier 250 is connected to the transmit port of the duplex filter 220.

- Next it will be described how a front end 200 according to Fig. 2 is integrated into a
30 single component in accordance with the invention.

Fig. 3a shows an example of an antenna structure according to the invention. What is essential is that the antenna as a component is board-like. Fig. 3a shows an antenna circuit board 310 which has on its lower surface, or second surface, which is

not visible in Fig. 3a, a ground plane 311 which covers substantially the whole area of the surface. On the upper surface, or first surface, of the circuit board 310 there are in this example three radiating elements: conductive areas 312, 313 and 314. Conductive areas 312 and 313 are planar, and if, in addition to having a common
5 feed, they are shorted to ground, they form a dual-frequency planar inverted-F antenna (PIFA). Conductive patch 314 comprises a meander-patterned conductor. It can be made to radiate at either of the PIFA frequency ranges or at some third frequency range. The board 310 is drawn in Fig. 3a considerably larger than its real size.

10 Fig. 3b illustrates a way of assembling the other functional units of the RF front end. Shown in Fig. 3b is a board-like piece 321 which may be a printed circuit board. Four modules 220, 230, 240 and 250 are placed on the board 321. The reference numerals correspond to those of Fig. 2. Module 220 comprises a duplex filter, module 230 a low-noise amplifier LNA, module 240 bandpass filters 241 and 242,
15 and module 250 comprises a power amplifier PA. In this example the filters are realized using coaxial resonators. In the figure is pointed to one resonator 325. Fig. 3b shows a pin-like conductor 323 the function of which is to provide a connection between the board 321 and antenna board 310. The conductor 323 is by its lower end connected to the filter 220 through a conductive strip 322. The other connections on the board 321 are not shown. The lower surface of the board 321, which is
20 not visible in Fig. 3b, is conductive. The board 321 and the modules on it are drawn considerably larger than they are in real life.

Fig. 4 shows an example of a front end assembled into a single component. The component 400 comprises an antenna circuit board 310, module assembly 320 and a
25 rigid mechanical frame 410. The frame 410 supports both the antenna board and board 321. Thereby is produced a protective housing for the filters and amplifiers. Fig. 4 shows a conductor 420 extending downward, which is one conductor between the component 400 and the rest of the communications apparatus. The parts shown in Fig. 4 are mechanically strong and firmly attached to each other so
30 that the component 400 formed is compact. In real life it is smaller than in the drawing.

Above it was described a solution according to the invention. The invention does not limit the number or size of the elements in the antenna board. Neither does the

invention limit the number or nature or internal realization of the RF units in the front end. The present invention is not limited to any particular application, too. It can be used in transceivers in various applications and at different frequencies and with different multiple access methods, advantageously at radio frequencies such as UHF and VHF. The arrangement according to the invention can be used in subscriber apparatus of a system based on digital time division multiple access (TDMA/FDMA, TDMA/FDD, or TDMA/TDD) that have a separate or integrated antenna, in car phones and in hand phones. The inventional idea can be applied in many ways within the scope defined by the independent claims.

Claims

1. A structure of a radio-frequency front end comprising as functional units an antenna and at least one bandpass filter and at least one amplifier, in which front end active and passive component parts have been integrated, **characterized** in that
 - 5 - it comprises an antenna circuit board on a first surface of which there is at least one radiating element and on a second surface of which there is a conductive plane,
 - said filters and amplifiers are supported by a second circuit board one surface of which is conductive,
 - it further comprises a protective frame such that the protective frame, antenna circuit board and said second circuit board form a substantially closed space,
 - 10 - the antenna circuit board, said second circuit board with attached units and said protective frame form a single solid component, and
 - the distance between said second printed circuit board and antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to any operating frequency of said front end.
2. The structure of claim 1, comprising both a transmit and a receive branch, **characterized** in that a duplex filter, a low-noise amplifier followed by a receive filter, a transmit filter followed by a power amplifier, and a directional coupler are said functional units.
- 20 3. The structure of claim 1, comprising both a transmit and a receive branch, **characterized** in that an antenna filter and antenna switch, a low-noise amplifier followed by a receive filter, a transmit filter followed by a power amplifier, and a directional coupler are said functional units.
4. The structure of claim 2 or 3, **characterized** in that further at least transmit and receive branch mixers, a modulator, a demodulator and the filters associated with these are said functional units.
- 25 5. The structure of claim 1, **characterized** in that said circuit board antenna is a multifrequency antenna that comprises at least two radiating elements.
6. A communications apparatus comprising a radio-frequency front end, **characterized** in that
 - 30 - said front end comprises an antenna circuit board on a first surface of which there are the radiating elements of the antenna of the communications apparatus and on a second surface of which there is a conductive plane,

- the other functional units in said front end are supported by a second circuit board one surface of which is conductive,
- said front end further comprises a protective frame such that the protective frame, the conductive second surface of the antenna circuit board and the conductive surface of said second circuit board form a substantially closed space,
- 5 - the antenna circuit board, said second circuit board with attached units and said protective frame form a single solid component,
- the distance between said second circuit board and antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to
- 10 any operating frequency of said front end,
- and in that said component is completely inside the covers of said communications apparatus.

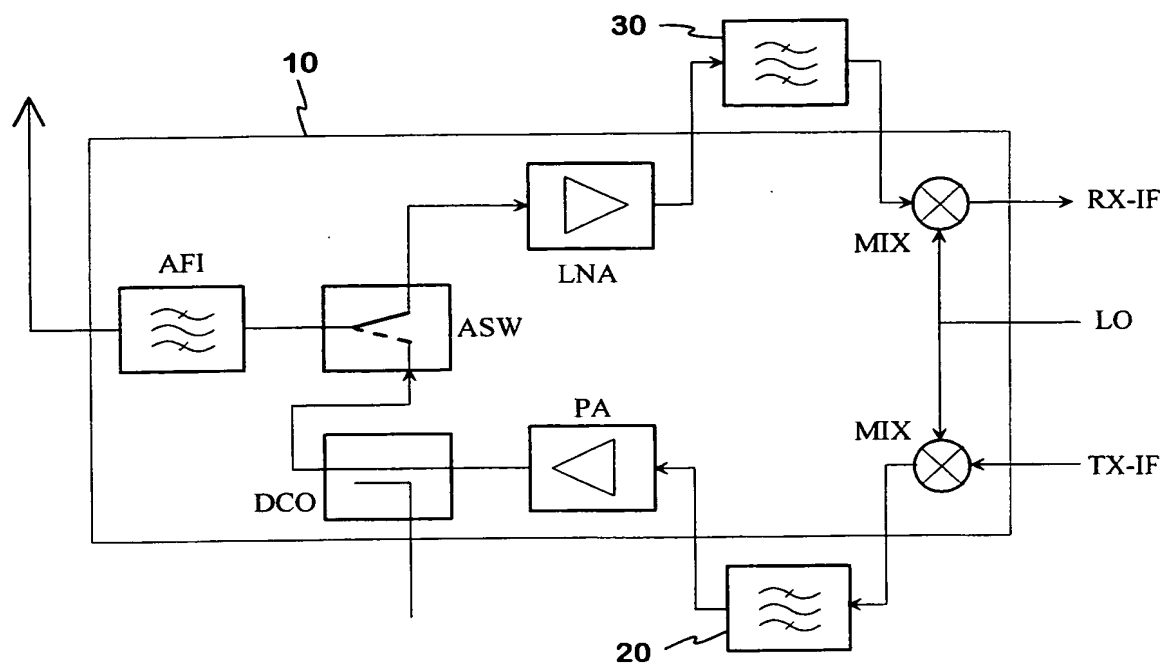


Fig. 1a

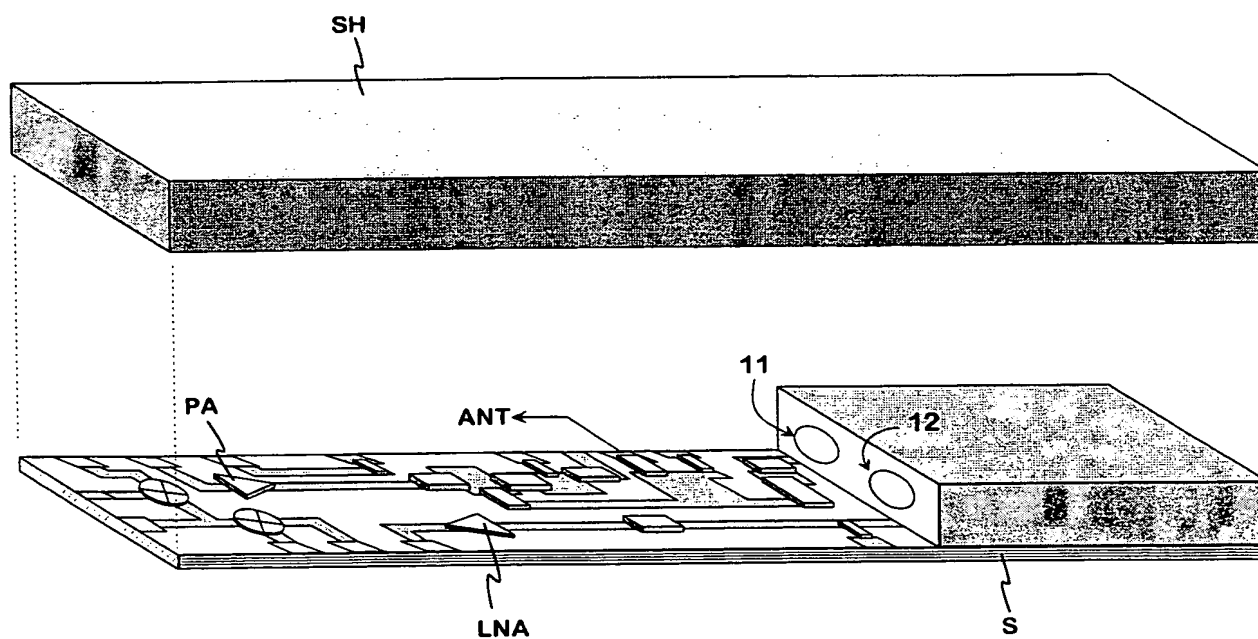


Fig. 1b

PRIOR ART

2/3

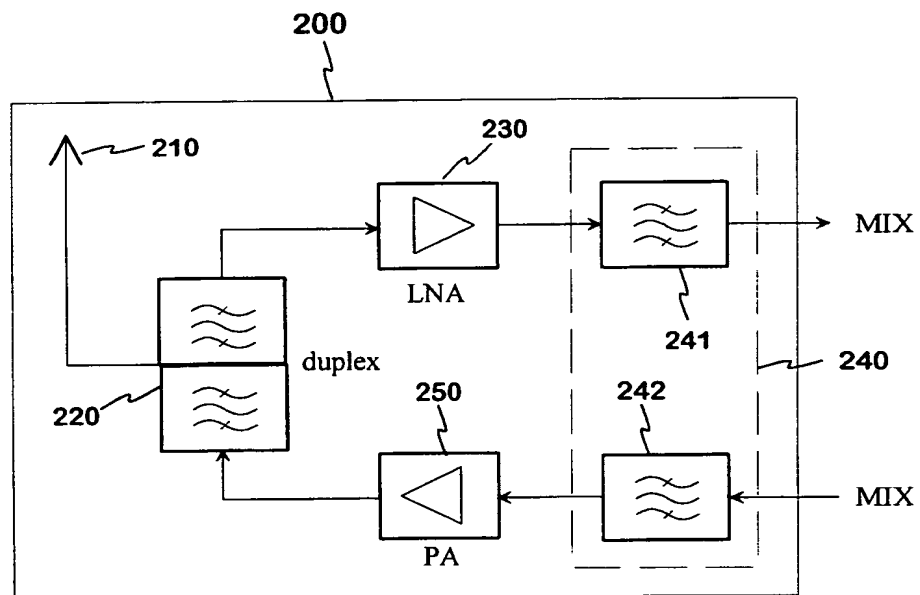


Fig. 2

3/3

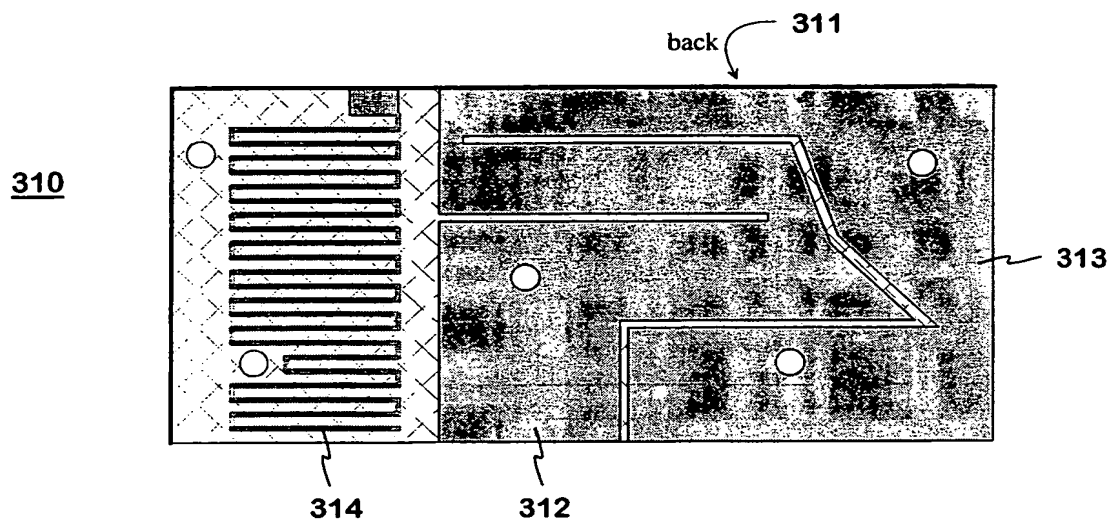


Fig. 3a

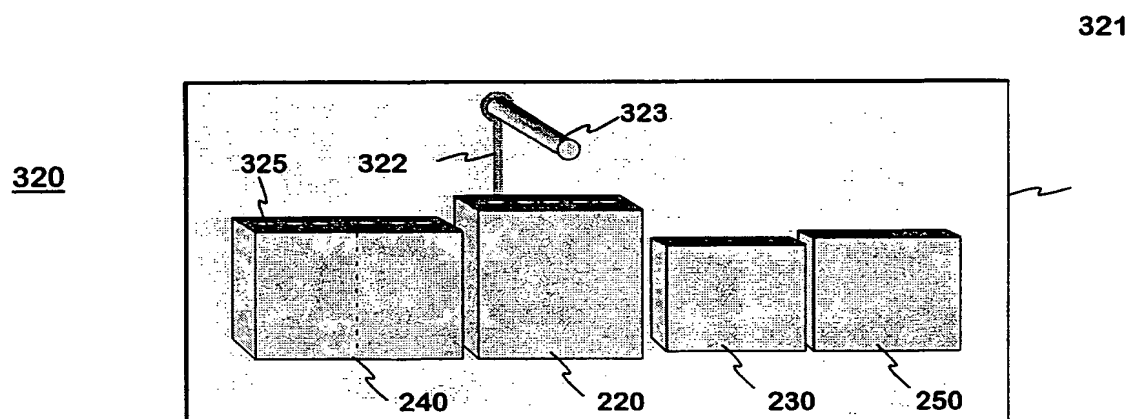


Fig. 3b

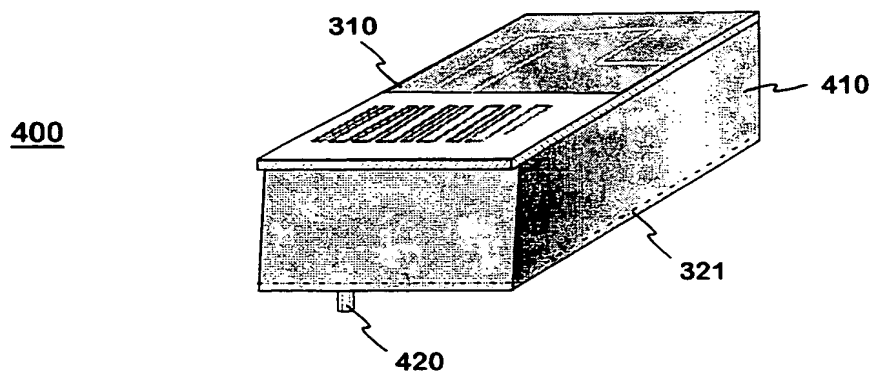


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 00/00644

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 1/40, H01Q 1/38, H04Q 9/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q, H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 19813767 A1 (KABUSHIKI KAISHA TOSHIBA), 8 October 1998 (08.10.98), column 4, line 61 - column 6, line 22, figure 3A --	1-6
A	EP 0766410 A2 (KABUSHIKI KAISHA TOSHIBA), 2 April 1997 (02.04.97), column 3, line 10 - column 4, line 13; column 7, line 43 - column 8, line 44, figures 6,7,36A,36B, abstract --	1-6
A	US 4792939 A (M. HIKITA ET AL.), 20 December 1988 (20.12.88), see the whole document --	1-6



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

25 October 2000

Date of mailing of the international search report

27-10-2000

Name and mailing address of the ISA/
Swedish Patent Office
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 00/00644

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5404581 A (K. HONJO), 4 April 1995 (04.04.95), see the whole document -----	1-6

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/10/00

International application No.

PCT/FI 00/00644

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
DE	19813767	A1	08/10/98	JP	10276113 A	13/10/98
EP	0766410	A2	02/04/97	JP	9153839 A	10/06/97
				US	5898909 A	27/04/99
US	4792939	A	20/12/88	JP	2089228 C	02/09/96
				JP	8004238 B	17/01/96
				JP	62171327 A	28/07/87
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